Modeling of dangerous phenomena and innovative techniques for hazard evaluation and risk mitigation

Giulio Iovine[a], Christoph Aubrecht[bc], Thomas Glade[d], Johannes Hübl[e] & Manuel Pastor[f]

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Society is frequently exposed to and threatened by dangerous phenomena in many parts of the world (Aubrecht, Özceylan et al. 2013; Iovine 2012). Different types of such phenomena require specific actions for proper risk management, from the stages of hazard identification to those of mitigation (including monitoring and early-warning) and/or reduction. The understanding of both predisposing factors and triggering mechanisms of a given danger and the prediction of its evolution from the source to the overall affected zone are relevant issues that must be addressed to properly evaluate a given hazard. Any assessment of potential damage should take into account the vulnerability of the elements at risk, present and expected, and possibly its varying spatial and temporal characteristics (Aubrecht et al. 2012; Aubrecht, Özceylan et al. 2013), including social, environmental, and structural components (Birkmann et al. 2013). Total risk evaluations should be carried out attentively on respective appropriate scales as facilitated by the quality of underlying input data and should provide supporting information for optimal selections of mitigation and/or reduction measures, based on expected impact scenarios, e.g. by comparison with past patterns (Aubrecht and Özceylan 2013).

Past disasters usually provide precious lessons that, combined with a proper planning of social settlements, may allow to minimizing the impact of future events. In fact, as the zero risk option is unrealistic, innovative approaches can be adopted to minimizing the residual risks, including integrated modeling and monitoring of hazardous phenomena, vulnerability evaluations and land use planning, knowledge dissemination and risk communication, and adoption of remedial measures (Aubrecht et al. in press). In case an area at risk is threatened by different types of phenomena, the evaluation of the overall risk and its mapping results becomes more complex (Kappes et al. 2012).

In the past decades, several approaches for risk evaluation have been proposed: qualitative and quantitative techniques have been tested against real case studies, at local or regional scales; modeling and sensitivity analyses have become more popular (Crisci et al. 2008; Iovine 2008); and real-time monitoring systems have become widespread, thus supporting warning procedures for civil protection purposes (Iovine et al. 2010; Capparelli et al. 2012). In this regard, some examples have recently been discussed in guest-edited special issues of relevant scientific journals (Aubrecht, Fuchs, and Neuhold 2013; Iovine, Di Gregorio, and Sheridan 2006; Iovine, Sheridan, and Di Gregorio 2006; Iovine et al. 2007, 2012; Iovine and Sheridan 2009a, 2009b; Iovine, Pastor, and Sheridan 2010; Iovine, Huebl et al. 2010; Parise and Iovine 2009; Parise et al. 2012).

The present special issue offers a selection of studies that cover a quite large spectrum of topics related to hazard evaluation and risk mitigation, including early warning and planning issues. Two out of five papers deal with modeling/simulation of slope movements, mainly focusing on run-out predictions. A third paper is focused on early warning of atmospheric hazards, while the remaining two deal with modeling of earthquake activity, and with problems of building reconstruction in urbanized sectors threatened by fires.

More in detail, Iannacone and co-workers discuss an example of simulation and sensitivity analysis of run out related to five different scenarios of failure of an active rockslide threatening a village in South Tyrol (Italy). Results obtained by varying friction and turbulent coefficients pointed out that, despite a large variability in the obtained values of run out, risk scenarios do not vary significantly except in the smallest case of failure. On the other hand, in the paper by Sanchez and co-workers (2013), a method to predict the propagation of short run out landslides is presented. The approach relies on a depth-integrated mathematical model including the coupling of soil skeleton and pore fluids, on suitable rheological relationships and on a meshless numerical method which separates the set of computational nodes from the one used to describing topographic features. Model validation is discussed by considering two examples with analytical solutions, and applied to two real cases occurred in Hong Kong in 1995.

Nastos and Matsangouras (2013) describe an early warning system for atmospheric hazards like storms, lightings, gale winds, snow, hail, tornadoes, low temperatures, and heat waves. It is intended to be used by local authorities for properly organizing and implementing plans to prevent and mitigate the impacts on humans and constructions. The system is linked to extensive Geographical Information Systems datasets and tools to allow for safety planning to mitigate the impacts of extreme atmospheric events. It involves high-resolution numerical modeling, networks for ground observation and lightning detection, and satellite data.

The study by Kechaidou and co-workers (2013) deals with earthquake data analysis in regions of Greece characterized by different seismicity levels. A new model is proposed based on evolutionary computation methods, such as symbolic regression by genetic programming and genetic algorithms to analyze hidden mathematical relations and patterns in seismological signals. The model is calibrated by reverse engineering, closing the loop from data collection to initial hypothesis. Geodynamic properties of the considered regions of Greece emerge from simulation results, in qualitative and quantitative terms.

In Osaragi's (2013) paper, the amelioration of building fireproofing is discussed, as the risk of widespread fires caused by severe earthquakes is extremely high in the Tokyo metropolitan area. A stochastic model is proposed to describe the conversion process of existing structures to eliminating the most hazardous sectors. Time-series changes in structure of a study district are simulated by applying extant urban planning and building codes. Piecemeal efficiency of regulations and their overall effectiveness in ameliorating fire risk in potentially hazardous zones are then commented.

The collection of papers of this special issue offers an interesting perspective on some recent approaches to risk analysis, and a particular focus on hazard issues with reference to different dangerous phenomena. Potentials and limits of the considered approaches can be inferred from the case studies and the related discussions. A generalized adoption of standard approaches for model evaluation and testing – as recently discussed by D'Ambrosio et al. (2013) – is still, unfortunately, only partially found in this field of research; if widely adopted, it may allow to better clarifying potentials and limits of the proposed techniques, thus permitting more sound applications.

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